CLAIMS

What is claimed is:

1. A micro-optic system comprising:

   a first collimating means for introducing a first input ordinary beam with wavelength λ_{1o} of a first pair of input beams,

   a second collimating means for introducing a first input extraordinary beam with wavelength λ_{1e} of said first pair of input beams,

   a third collimating means for introducing a second input ordinary beam with wavelength λ_{2o} of a second pair of input beams,

   a fourth collimating means for introducing a second input extraordinary beam with wavelength λ_{2e} of said second pair of input beams,

   a polarization beam combiner for combining said first pair of input beams and said second pair of input beams into a first combined light beam with wavelength λ_1 and a second combined light beam with wavelength λ_2, and

   a filter for multiplexing said first combined light beam and said second combined light beam into an output beam,

   wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

2. The micro-optic system of claim 1, further comprising a fifth collimating means for receiving said output beam.

3. The micro-optic system of claim 2, wherein said first collimating means, said second collimating means and said fifth collimating means are the same one.

4. The micro-optic system of claim 1, wherein said third collimating means and said fourth collimating means are the same one.

5. The micro-optic system of claim 2, further comprising:

a first subassembly holding an end of a first fiber in paraxial relationship with said first collimating means,

a second subassembly holding an end of a second fiber in paraxial relationship with said second collimating means,

a third subassembly holding an end of a third fiber in paraxial relationship with said third collimating means,

a fourth subassembly holding an end of a fourth fiber in paraxial relationship with said fourth collimating means, and

a fifth subassembly holding an end of a fifth fiber in paraxial relationship with said fifth collimating means,

wherein said first fiber, said second fiber, said third fiber and said fourth fiber are polarization-maintaining optical fibers, said fifth fiber is a single mode optical fiber.

6. The micro-optic system of claim 2, wherein said first collimating means, said second collimating means, said

third collimating means, said fourth collimating means and said fifth collimating means each comprises a lens selected from a group consisting of GRIN lens, spherical lean and aspherical lens.

7. The micro-optic system of Claim 1, wherein said polarization beam combiner comprises at least one birefringent crystal.

8. The micro-optic system of claim 7, wherein said birefringent crystal comprises a material selected from group consisting of Calcite, YVO_4, Rutile and $LiNbO_3$.

9. The micro-optic system of claim 1, wherein said polarization beam combiner comprises a prism selected from the group consisting of Glan polarizing prism, right angle prism coated with thin film, Nicol prism, Wollaston prism, Rochon prism and Sénarmont prism.

10. The micro-optic system of claim 1, wherein said polarization beam combiner comprising:

a first wedge,

a second wedge, and

a Faraday rotator disposed between said first wedge and said second wedge,

wherein said first wedge, said faraday rotator and said second wedge are cascaded along an optical axis.

11. The micro-optic system of claim 1, wherein said filter is disposed before said polarization beam combiner.

12. The micro-optic system of claim 1, wherein said filter is disposed after said polarization beam combiner.

13. The micro-optic system of claim 1, wherein said filter is disposed inside said polarization beam combiner.

14. The micro-optic system of claim 1, wherein said filter comprises a device selected from a group consisting of grating and thin film.

15. A micro-optic system comprising:

a fifth collimating means for introducing an input beam with wavelength λ_1 and wavelength λ_2,

a filter for de-multiplexing said input beam into a first de-multiplexed light beam with wavelength λ_1 and a second de-multiplexed light beam with wavelength λ_2, and

a polarization beam splitter for splitting said first de-multiplexed light beam and said second de-multiplexed light beam into a first pair of output beams comprising a first output ordinary beam with wavelength λ_{1o} and a first output extraordinary beam with wavelength λ_{1e} and a second pair of output beams comprising a second output ordinary beam with wavelength λ_{2o} and a second output extraordinary beams with wavelength λ_{2e},

wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

16. The micro-optic system of claim 15, further comprising:

a first collimating means for receiving said first output ordinary beam,

a second collimating means for receiving said first output extraordinary beam,

a third collimating means for receiving said second output ordinary beam,

a fourth collimating means for receiving said second output extraordinary beam.

17. The micro-optic system of claim 16, wherein said first collimating means and said second collimating means are the same one.

18. The micro-optic system of claim 16, wherein said third collimating means and said fourth collimating means are the same one.

19. The micro-optic system of claim 16, further comprising:

a first subassembly holding an end of a first fiber in paraxial relationship with said first collimating means,

a second subassembly holding an end of a second fiber in paraxial relationship with said second collimating means,

a third subassembly holding an end of a third fiber in paraxial relationship with said third collimating,

a fourth subassembly holding an end of a fourth fiber in paraxial relationship with said fourth collimating means, and

a fifth subassembly holding an end of a fifth fiber in paraxial relationship with said fifth collimating means,

wherein said fifth fiber is a single mode optical fiber.

20. The micro-optic system of claim 19, wherein each of said first fiber, said second fiber, said third fiber, and said fourth fiber comprises an optical fiber selected from a group consisting of polarization maintaining optical fiber and single mode optical fiber.

21. The micro-optic system of claim 16, wherein said first collimating means, said second collimating means, said third collimating means, said fourth collimating means and said fifth collimating means each comprises a lens selected from a group consisting of GRIN lens, spherical lens and aspherical lens.

22. The micro-optic system of claim 15, wherein said polarization beam splitter comprises a prism selected from the group consisting of Glan polarizing prism, right angle prism coated with thin film, Nicol prism, Wollaston prism, Rochon prism and Sénarmont prism.

23. The micro-optic system of claim 15, wherein said polarization beam splitter comprising:

a first wedge,

a second wedge, and

a Faraday rotator disposed between said first wedge and said second wedge,

wherein said first wedge, said faraday rotator and said second wedge are cascaded along an optical axis.

24. The micro-optic system of claim 15, wherein said filter is disposed before said polarization beam splitter.

25. The micro-optic system of claim 15, wherein said filter is disposed after said polarization beam splitter.

26. The micro-optic system of claim 15, wherein said filter is disposed inside said polarization beam splitter.

27. A micro-optic system comprising:

a first collimating means for introducing a first input ordinary beam with wavelength λ_{1o} of a first pair of input beams,

a second collimating means for introducing a first input extraordinary beam with wavelength λ_{1e} of said first pair of input beams,

a third collimating means for introducing a second input ordinary beam with wavelength λ_{2o} of a second pair of input beams,

a fourth collimating means for introducing a second input extraordinary beam with wavelength λ_{2e} of said second pair of input beams,

a polarizing prism having a first half with a first external surface and a second external surface, and a second half with a third external surface opposing to said second external surface and a fourth external surface opposing to said first external surface, the centers of said second external surface and said

third external surface defining an optical axis, said first half combining said first pair of input beams which are incident on said first external surface into a first combined light beam with wavelength λ_1, said second half and said first half combining said second pair of input beams which are incident on said third external surface into a second combined light beam with wavelength λ_2, and

a filter disposed between said first half and said second half, said filter reflecting light beam with wavelength λ_1 and being transparent to light beam with wavelength λ_2, thereby said filter multiplexing said first combined light beam and said second combined light beam into an output beam along said optical axis,

wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

28. The micro-optic system of claim 27, further comprising a fifth collimating means for receiving said output beam.

29. The micro-optic system of claim 28, further comprising:

a first subassembly holding an end of a first fiber in paraxial relationship with said first collimating means,

a second subassembly holding an end of a second fiber in paraxial relationship with said second collimating means,

a third subassembly holding an end of a third fiber in paraxial relationship with said third collimating means,

a fourth subassembly holding an end of a fourth fiber in paraxial relationship with said fourth collimating means, and

a fifth subassembly holding an end of a fifth fiber in paraxial relationship with said fifth collimating means,

wherein said first fiber, said second fiber, said third fiber and said fourth fiber are polarization-maintaining optical fibers, said fifth fiber is a single mode optical fiber.

30. The micro-optic system of claim 28, wherein said first collimating means, said second collimating means, said third collimating means, said fourth collimating means and said fifth collimating means each comprises a lens selected from a group consisting of GRIN lens, spherical lens and aspherical lens.

31. The micro-optic system of claim 27, wherein said polarizing prism comprises a prism selected from the group consisting of Wollaston prism, Rochon prism and Sénarmont prism.

32. The micro-optic system of claim 27, wherein said filter comprises a device selected from a group consisting of grating and thin film.

33. A micro-optic system comprising:

a fifth collimating means for introducing an input beam with wavelength λ_1 and wavelength λ_2,

a polarizing prism having a first half with a first external surface and a second external surface, and a second half with a third external surface opposing to said second external surface and a fourth external surface opposing to said first external surface, the centers of said second external surface and said third external surface defining an optical axis, and

a filter disposed between said first half and said second half, said filter reflecting light beam with wavelength λ_1 and being transparent to light beam with wavelength λ_2, thereby said filter de-multiplexing said input light beam which is incident along said optical axis on said second external surface into a first de-multiplexed light beam with wavelength λ_1 and a second de-multiplexed light beam wavelength λ_2, said first half splitting said first de-multiplexed light beam into a first pair of output beams comprising a first output ordinary beam with wavelength λ_{1o} and a first output extraordinary beam with wavelength λ_{1e}, said second half splitting said second de-multiplexed light beam into a second pair of output beams comprising a second output ordinary beam with wavelength λ_{2o} and a second output extraordinary beams with wavelength λ_{2e},

wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

34. The micro-optic system of claim 33, further comprising:

a first collimating means for receiving said first output ordinary beam,

a second collimating means for receiving said first output extraordinary beam,

a third collimating means for receiving said second output ordinary beam,

a fourth collimating means for receiving said second output extraordinary beam.

35. The micro-optic system of claim 34, further comprising:

a first subassembly holding an end of a first fiber in paraxial relationship with said first collimating means,

a second subassembly holding an end of a second fiber in paraxial relationship with said second collimating means,

a third subassembly holding an end of a third fiber in paraxial relationship with said third collimating means,

a fourth subassembly holding an end of a fourth fiber in paraxial relationship with said fourth collimating means, and

a fifth subassembly holding an end of a fifth fiber in paraxial relationship with said fifth collimating means,

wherein said fifth fiber is a single mode optical fiber.

36. The micro-optic system of claim 35, wherein each of said first fiber, said second fiber, said third fiber, and said fourth fiber comprises an optical fiber selected

from a group consisting of polarization maintaining optical fiber and single mode optical fiber.

37. A micro-optic system comprising:

a first collimating means for introducing a first input ordinary beam with wavelength λ_{1o} of a first pair of input beams,

a second collimating means for introducing a first input extraordinary beam with wavelength λ_{1e} of said first pair of input beams,

a third collimating means for introducing a second input ordinary beam with wavelength λ_{2o} of a second pair of input beams,

a fourth collimating means for introducing a second input extraordinary beam with wavelength λ_{2e} of said second pair of input beams,

a polarization beam combiner comprising:

a first wedge,

a second wedge, and

a +45° Faraday rotator disposed between said first wedge and said second wedge,

wherein said first wedge, said faraday rotator and said second wedge are cascaded along a optical axis in a forward direction, said second wedge is oriented 45° with respect to said first wedge in the same direction as the rotation caused by said Faraday rotator, and

a filter disposed after said second wedge, said first pair of input beams being incident in said forward direction on said first wedge symmetrically with respect to said optical axis with a predetermined

convergent angle between each other, propagating through said first wedge, said Faraday rotator and said second wedge, and then being incident on said filter, said second pair of input beams being incident in a backward direction opposite to said forward direction on said filter symmetrically with respect to said optical axis with a predetermined convergent angle between each other, said filter reflecting said first pair of input beams and being transparent to said second pair of input beams, thereby said polarization beam combiner combining said first pair of input beams into a first combined light beam with wavelength λ_1 in said backward direction along said optical axis and said second pair of input beams into a second combined light beam with wavelength λ_2 in said backward direction along said optical axis, and said filter multiplexing said first combined light beam and said second combined light beam into an output beam,

wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

38. The micro-optic system of claim 37, further comprising a fifth collimating means for receiving said output beam.

39. The micro-optic system of claim 38, wherein said first collimating means, said second collimating means and said fifth collimating means share a first collimator, said third collimating means and said fourth collimating means share a second collimator, said first collimator

is positioned before said first wedge, said second collimator is positioned after said filter.

40. The optical system of claim 39, further comprising:

a first subassembly holding an end of a first fiber,

a second subassembly holding an end of a second fiber, said first fiber and said second fiber being polarization-maintaining fibers being positioned before said first collimator and parallel to said optical axis, the tips of said first fiber and said second fiber being one focus away from said first collimator, the polarization directions of said first fiber and said second fiber being 90 degree apart from each other for introducing said first pair of input beams,

a third subassembly holding an end of a third fiber,

a fourth subassembly holding an end of a fourth fiber, said third fiber and said fourth fiber being polarization-maintaining fibers being positioned after said second collimator and parallel to said optical axis, the tips of said third fiber and said fourth fiber being one focus away from said second collimator, the polarization directions of said third fiber and said fourth fiber being 90 degree apart from each other for introducing said second pair of input beams, and

a fifth subassembly holding an end of a fifth fiber, said fifth fiber being positioned before said first collimator and along said optical axis, the tip of said fifth fiber being one focus away from said first

collimator, said fifth fiber being a single mode optical fiber for receiving said output beam.

41. The optical system of claim 40, further comprising:

a first polarizer disposed in front of said first fiber, the polarization direction of said first polarizer being same as that of said first fiber, and

a second polarizer disposed in front of said second fiber, the polarization direction of said second polarizer being same as that of said second fiber,

wherein the backing light beams of said first combined light beam from said fifth fiber are reflected by said filter and blocked by said first polarizer and said second polarizer respectively from entering into said first fiber and said second fiber, and the backing light beams of said second combined light beam from said fifth fiber pass through said polarization beam combiner and said filter and become parallel to said optical axis, thereby being prevented from entering into said third fiber and said fourth fiber.

42. The micro-optic system of claim 41, further comprising:

a six subassembly holding an end of a sixth fiber, said sixth fiber being a single mode optical fiber disposed after said second collimator along said optical axis, the tip of said sixth fiber being one focus away from said second collimator,

wherein the light beam with telecommunication signals propagating in said forward direction from said fifth fiber passes through said first collimator, said

polarization beam combiner, said filter and said second collimator and then enters into said sixth fiber.

43. The micro-optic system of claim 41, wherein said output beam is a combination of said first pair of input beams and said pair of input beams for pumping a Raman amplifier.

44. The micro-optic system of claim 43, wherein said wavelength λ_1, said wavelength λ_{1o}, and said wavelength λ_{1e} are substantially 1435 nm, said wavelength λ_2, said wavelength λ_{2o}, and said wavelength λ_{2e} are substantially 1455 nm.

45. The micro-optic system of claim 43, wherein said output light beam a combination of said first pair of input beams and said second pair of input beams for pumping an EDFA.

46. The micro-optic system of claim 37, wherein said filter comprises a device selected from a group consisting of grating and thin film.

47. A micro-optic system comprising:

a fifth collimating means for introducing an input beam with wavelength λ_1 and wavelength λ_2,

a polarization beam splitter comprising:

a first wedge,

a second wedge, and

a +45° Faraday rotator disposed between said first wedge and said second wedge,

wherein said first wedge, said faraday rotator and said second wedge are cascaded along an optical axis in a forward direction, said second wedge is oriented 45° with respect to said first wedge in the opposite direction as the rotation caused by said Faraday rotator, and

a filter disposed after said second wedge, said input beam being incident along said optical axis, passing through said polarization beam splitter and then incident on said filter, said filter reflecting the portion of light beams with wavelength λ_1 of said input beam and being transparent to the portion of light beams with wavelength λ_2 of said input beam, thereby said filter de-multiplexing said input beam into a first de-multiplexed light beam with wavelength λ_1 and a second de-multiplexed light beam with wavelength λ_2, said polarization beam splitter splitting said first de-multiplexed light beam into a first pair of output beams comprising a first output ordinary beam with wavelength λ_{1o} and a first output extraordinary beam with wavelength λ_{1e} in a backward direction opposite to said forward direction symmetrically with respect to said optical axis with a predetermined diverging angle between each other, and said second de-multiplexed light beam into a second pair of output beams comprising a second output ordinary beam with wavelength λ_{2o} and a second output extraordinary beams with wavelength λ_{2e} in said forward direction symmetrically with respect to said optical axis with a predetermined diverging angle between each other,

wherein said wavelength λ_1 equals to said wavelength λ_{1o} and said wavelength λ_{1e}, said wavelength λ_2 equals to said wavelength λ_{2o} and said wavelength λ_{2e}.

48. The optical system of claim 47, further comprising:

a first collimating means for receiving said first output ordinary beam,

a second collimating means for receiving said first output extraordinary beam,

a third collimating means for receiving said second output ordinary beam,

a fourth collimating means for receiving said second output extraordinary beam.

49. The optical system of claim 48, wherein said first collimating means, said second collimating means and fifth collimating means share a first collimator, said third collimating means and said fourth collimating means share a second collimator, said first collimator is positioned before said first wedge, said second collimator is positioned after said filter.

50. The optical system of claim 49, further comprising:

a first subassembly holding an end of a first fiber,

a second subassembly holding an end of a second fiber, said first fiber and said second fiber being positioned before said first collimator and parallel to said optical axis, the tips of said first fiber and said second fiber being one focus away from said first collimator, the polarization directions of said first fiber and said second fiber being 90 degree apart from

each other for receiving said first pair of input beams,

a third subassembly holding an end of a third fiber,

a fourth subassembly holding an end of a fourth fiber, said third fiber and said fourth fiber being positioned after said second collimator and parallel to said optical axis, the tips of said third fiber and said fourth fiber being one focus away from said second collimator, the polarization directions of said third fiber and said fourth fiber being 90 degree apart from each other for receiving said second pair of input beams, and

a fifth subassembly holding an end of a fifth fiber, said fifth fiber being positioned before said first collimator and along said optical axis, the tip of said fifth fiber being one focus away from said first collimator for introducing said input beam,

wherein said fifth fiber is a single mode optical fiber.

51. The micro-optic system of claim 50, wherein each of said first fiber, said second fiber, said third fiber, and said fourth fiber comprises an optical fiber selected from a group consisting of polarization maintaining optical fiber and single mode optical fiber.